HAWKER

HAWKER BATTERIES

INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS FOR

TUNGSTONE

VENTED LEAD ACID BATTERY CELLS

PLANTE

HAP ▪ HBS ▪ HBP ▪ HCP & UHBP TYPES

FLAT PLATE

TPA(C) ▪ TPB(C) ▪ & TPC(C) TYPES

TECHNICAL MANUAL

FOR THE INSTALLATION, OPERATION AND MAINTENANCE OF TUNGSTONE PLANTÉ AND FLAT PLATE BATTERY CELLS

HAP, HBS/HBP, HCP, UHBP AND TPA(C), TPB(C), TPC(C) TYPES

FOREWORD

Batteries are often the last line of defence in providing electrical energy after the main power supply has failed. This manual provides the user with information for optimising performance and life at minimum cost.

Essential information regarding the Health & Safety of personnel coming into contact with, or working close to batteries is given. Storage and operating instructions including service requirements are fully detailed. Commissioning procedures are re defined and clarified.

The High Performance Planté product is a highly reliable power source offering 100% capacity throughout the battery's life. Pasted Plate types offer a more compact power source. Both types will give a long and reliable life if installed, commissioned, operated and serviced in accordance with these instructions.

Important:-

Warranties are only valid if cells/monoblocs have been installed, operated, and maintained in accordance with the instructions in this manual.

Furthermore completed record sheets to demonstrate this are required against any warranty claim.

This entire manual should be read prior to storage, installation or putting into service. The installation and erection of batteries should be undertaken by suitably qualified engineers only.

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VENTED LEAD ACID BATTERIES
INSTALLATION, OPERATING AND SERVICE INSTRUCTIONS

CONTENTS

1. SCOPE AND SAFETY WARNINGS

Planté/Flat Plate batteries are hazardous. Take note of the meanings of the following symbols and information.

No smoking, no naked flames, no sparks

Sulphuric acid

Contains explosive gases.

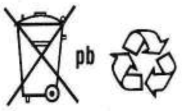
Shield eyes

Note operating instructions

Keep away from children. Care by authorised personnel only.

Danger!

Electrical hazard



Do not throw into refuse bins. Re-cycle scrap batteries: return to a registered carrier for the disposal of scrap batteries (Tungstone Batteries Ltd is a registered carrier). Contains lead.

The information contained in this manual must be read in conjunction with BS 6133: British Standard Code of Practice for the Safe Operation of Lead Acid Stationary Cells and Batteries latest issue. Reference should also be made to the Companies Secondary Lead Acid Batteries, Health & Safety Information Sheet; a copy of which is available upon request.

****** HEALTH AND SAFETY WARNING ******

The immediate risks are electric shock, chemical burns from the electrolyte, sparks from short circuits and explosion of evolved hydrogen gas.

Always wear goggles, rubber gloves, and preferably protective clothing, when working on the battery or with the electrolyte which is sulphuric acid. Ensure that the Battery Care Warning Card and this manual, which are supplied with all batteries, are in a prominent position near the battery and are kept in the transparent plastic wallet provided. Battery rooms and/or cabinets should be locked against unauthorised access. Take care that short circuits are not caused by accidentally dropping or touching metal objects onto the cell or monobloc terminals.

Never permit smoking, sparks or any kind of flames near the battery. Ensure that the installation and service staff are not wearing metal adornments such as a watch or ring which could cause short circuits and personal injury. Synthetic clothing such as "nylon" should not be worn. Ensure that staff earth themselves to discharge any static electricity before working on the battery. Always use insulated tools. Sparks can ignite gases given off by the battery resulting in violent explosions.

On high voltage batteries (120V or above 60 cells) never work alone. Approved high voltage insulating gloves must be worn. The battery must be "split" into safe voltage sections before commencing any other work, apart from normal servicing.

****** FOR THE BATTERIES HEALTH AND SAFETY ******

Should your main power supply fail, a battery is normally the last line of defence against system failure. Service schedules should reflect the fact that lives may depend on reliable operation under emergency conditions.

When topping up add only purified water. Never add any kind of electrolyte or conditioner except under direct written instructions from the Company.

Never work on the battery with tools which have previously been used on a nickel cadmium battery without neutralising and cleaning beforehand. Cross contamination can destroy a battery.

Keep the battery clean, maintain the electrolyte level between the maximum and minimum lines, check cell or monobloc and battery connections for tightness and keep well coated with no-oxide grease. Ensure that the battery charging system is operating correctly.

****** IN EMERGENCIES ******

ACID ELECTROLYTE

The electrolyte in vented lead acid batteries is dilute sulphuric acid, having a concentration of approximately 30%. It is poisonous and corrosive, which may cause burns and irritation to the skin and there is a risk of serious damage to eyes. If spilt on clothing it may attack materials made of natural or synthetic fibres.

ACID IN CONTACT WITH EYE

Speed of action is vital. Immediately irrigate the eye with clean, cold water or eye wash solution, for at least 10 to 15 minutes and seek medical attention immediately. An eye wash station should be provided in the battery room.

ACID IF SWALLOWED

Do not induce vomiting but make the patient drink as much plain water or milk as possible; seek medical attention immediately.

ACID IN CONTACT WITH SKIN

Remove contaminated clothing immediately and drench the affected area with copious quantities of clean water. If soreness or irritation occurs seek medical attention.

ACID SPILLAGE

Wear appropriate protective clothing. If local conditions permit, small spillages can be either swilled away with copious quantities of water or first spread soda ash or hydrated lime liberally over the spillage then mop up cautiously with plenty of water and run to waste, diluting greatly with water.

Large spillages should be ringed with neutralising agent (Soda Ash or Hydrated Lime) and gradually soaked up with further neutralising agent, sand or earth. Liquids and solids should be transferred to salvage containers and any residual treated as small spillage.

ELECTRICITY

Electrical energy can be supplied from both batteries and charging equipment. A discharged or damaged battery may still supply high currents and voltage.

ELECTRIC SHOCK

Protect yourself first. Do not touch a victim unless you are sure that it is safe to do so. If the victim is still touching the electricity source, first isolate. If it is not possible to isolate use insulating rubber gloves to pull the victim clear. Give artificial respiration if required. In all cases of electric shock, seek medical assistance immediately.

ELECTRIC BURNS

Once clear of the source, hold the affected area under running water for 10 minutes if possible and seek medical attention immediately.

EXPLOSIONS

Explosions in batteries are very rare but can be extremely violent. The usual cause is a spark igniting the explosive gasses that are given off. In case of explosion, evacuate the area and treat any victims as directed above; seek medical assistance immediately and then isolate the battery.

2. INTRODUCTION

The Company can supply two alternative types of vented lead acid cells described in this publication, Planté and Pasted Plate.

2.1 High Performance Planté

Two different types of Planté cells are available from the Company, High Performance and Ultra High Performance. The Ultra High Performance Planté type is unique to the Company.

Three distinct sizes are available prefixed HAP, HBS/HBP & HCP, where the primary difference is plate area.

Note: HBS and HBP are identical apart from the cell terminal.

The Ultra High Performance Planté types are prefixed UHBP.

The containers are injection moulded clear SAN for ease of servicing and mechanical stability. The lids are green or orange SAN "wrap over" style for ease of cleaning. The Planté range is easily identified because the positive plates are hung from shoulders integrally moulded in the containers. Excepting HCP, the type is identified by an identification disc round the positive terminal. The cell type range, HAP, HBS/HBP or UHBP and a series of numbered segments are moulded onto the disc which is aligned with an arrow head or pip moulded on the lid, see Figure 2.1. For the HCP cell type, the top of the positive pillar is stamped with the cell type reference, e.g. HCP41.

2.2 Pasted Plate

Two types are available, Mainstay and Powerbloc. The Mainstay range is available in either low antimony lead alloy or calcium lead alloy.

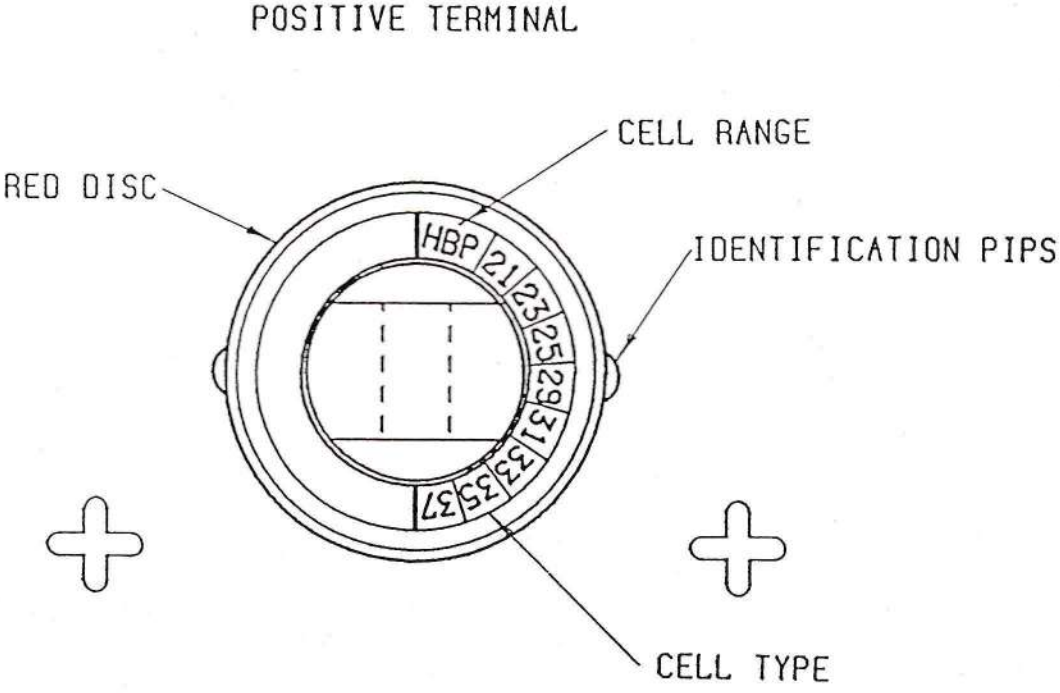
The Mainstay range meets BS 6290 Parts 1 & 3. The method of construction complies with DIN specifications and European OGI standards. Three distinct sizes are available prefixed TPA, TPB & TPC for lead antimony alloy types, where the primary difference is plate area. Suffix "C" types TPAC, TPBC & TPCC, utilise a lead calcium alloy. Both have clear SAN containers and lids of either green or orange SAN "wrap over" style. Cell type identification is similar to Planté.

The Powerbloc Low Maintenance range is an economic and compact range of pasted plate 6 volt monoblocs. The containers and lids are heat sealed robust polypropylene.

2.3 Specifications

Details on individual cell and monoblocs general specification are given in separate publications. For details, contact our company.

FIGURE 2.1



Cell Identification - HAP, PM, TPA(C), HBS/HBP, TPB(C) & UHBP Ranges

Note: If "HBP" sector is opposite pip - cell type will appear on a separate label.

Cell Identification - HCP and TPC(C) Ranges

The cell type is die stamped on the positive terminal pillar.

Cell Identification - Powerbloc Range

The cell type is denoted by a small depression marked on the cell lid by the red positive terminal ring.

2.4 Electromagnetic Compatibility

Rechargeable cells or batteries are not sensitive to normal electromagnetic disturbances and therefore no immunity tests shall be required. Free standing rechargeable cells or batteries electrically isolated from any associated electrical system are for all practical purposes electromagnetically inert, and therefore the requirements for electromagnetic compatibility (EMC Directive 89/336/EEC) shall be deemed to be satisfied.

Note: It should be noted that rechargeable cells or batteries are part of an electrical system and the manner in which they are used could invoke the requirements of electromagnetic compatibility upon that system. In such cases, the requirements of electromagnetic compatibility shall be accommodated by the design of the system.

For further information refer to prEN 50226.

3. STORAGE

If the battery is not to be used immediately, certain criteria MUST be observed if it is to remain in good condition ready for commissioning. The maximum period for which the product can be stored depends on the condition in which it is supplied. The specific condition should be clearly stated at the time the order is placed.

3.1 Storage Conditions

The product must first be unpacked and checked, see section 4. It must be stored in a clean, dry and well ventilated room having good natural or artificial lighting. Product must not be placed in direct sunlight. The cells may be stored on a battery stand, open shelving or in the battery cabinet or cubicle for which it is intended, providing good ventilation and access for inspection are provided. If this type of storage is not available, the product may be stored in the packing cases provided the tops are removed to provide ventilation to the cells.

Where product is supplied in sealed polythene bags, these MUST be opened and the cell or monobloc removed. For storage in the packing case, the cell or monobloc need not be removed from the bag providing it is opened and turned down to provide ventilation to the cell or monobloc tops.

In no circumstances shall units be covered with any material such as plastic sheeting, this will not permit adequate ventilation.

In order to protect the terminals from the effects of climatic conditions, eg oxidation, the cell terminals MUST be liberally coated with no-oxide grease. Cell types HCP, TPC and TPCC require special consideration. For these types the plastic polarity disc (red positive and black negative) MUST be removed, the pillar greased down into the lid well and the polarity disc refitted. The disc is free fitting - no adhesive is used or required. It is imperative that the correct coloured disc is fitted to each positive and negative terminal, therefore all positive terminals should be treated and all red discs refitted before work on the negative terminals is commenced.

For other cell types, the polarity discs cannot be removed. The pillars down to the polarity discs should be liberally coated with no-oxide grease.

Where pillar shrouding is provided, this MUST be refitted after applying the no-oxide grease.

Connectors, cable lugs and nut and bolt sets etc MUST also be protected against the effects of climatic conditions. This is best achieved by liberally coating all parts with no-oxide grease.

3.2 Storage Times for Cells or Monoblocs Supplied Filled and Nominally Charged

4 months up to 20°C
2 months up to 30°C
1 month up to 40°C

If the storage times and/or temperature limits are exceeded, permanent damage and loss of capacity may result. If the battery is to be stored prior to commissioning for a period greater than stated for the relevant average temperature, it must undergo a charge as detailed in Section 10. It should receive further charges as appropriate for storage temperature until such time as it is commissioned.

3.3 Storage Times for Cell or Monoblocs Supplied Dry Charged

12 months up to 20°C
6 months up to 30°C
3 months up to 40°C

The above storage times are applicable to a relative humidity of 50%. The storage time is progressively reduced to half that given above at a relative humidity of 100%.

If the storage times and/or temperature limits are exceeded, the product may lose its Dry Charged characteristics and is then described as Time Expired Dry Charged. An extended commissioning charge will be required which may be up to twice as long as that required for product stored for the times given above. Further details are given in Section 10.

Dry Charged, Time Expired cells have an indefinite storage time.

3.4 Storage Times for Cells or Monoblocs Supplied Dry Formed

Providing the product is stored as detailed above, these types have an indefinite storage time.

4. UNPACKING

DANGER

CELLS OR MONOBLOCS SUPPLIED FILLED AND CHARGED CONTAIN CORROSIVE AND POISONOUS SULPHURIC ACID AND ARE ELECTRICALLY LIVE.

Carefully examine the consignment for any obvious signs of transit damage and that it agrees with the materials list or consignment note. If any damage or shortages are evident, advise the carriers immediately in writing and send a copy of the letter to our company.

Be very careful not to inadvertently discard any accessories concealed in the packing material.

If the product has been supplied in a filled and charged condition it is normal that the electrolyte level will be a little below the "maximum" level. This occurs because gas bubbles created during factory charging are not always dispersed before despatch but do disperse in transit. Abnormally low levels below the "minimum" level must be reported to our company and we would advise that the cell or monobloc is examined for signs of transit damage.

Product supplied filled and nominally charged will have an electrolyte specific gravity below that for fully charged units because of self discharge occurring after factory charging.

Immediately after unpacking, the cell terminals MUST be liberally coated with no-oxide grease, see Section 3, Storage.

CELLS OR MONOBLOCS MUST NOT BE LIFTED BY THE TERMINALS.

5. BATTERY ROOM DESIGN CRITERIA

All vented lead acid batteries give off hydrogen and oxygen when being charged, the major gassing generally occurring towards the end of the charging period or during any boost charging or overcharging of the battery. The electrolyte is corrosive sulphuric acid. These two main characteristics must be carefully considered at the battery room design stage.

The battery room should be dry, well ventilated and have a sulphuric acid resistant finish. For large batteries, forced ventilation and a tiled floor are recommended. The room should be well lit.

The battery will operate satisfactorily over a wide temperature range of between -20°C and 40°C, but life or performance will be impaired. For optimum service life and performance an electrolyte temperature of 20°C ± 5°C should be maintained. The battery must not be placed in direct sunlight.

First Aid and Eye Wash equipment should be readily available inside the battery room. A sink with tap water is recommended and for large installations a shower should be provided.

Protective clothing including goggles and rubber gloves should be in the battery room.

A suitable NO SMOKING sign should be placed in a prominent position inside the battery room and on the outside of the battery room door which should be locked allowing access by authorised personnel only.

Many batteries are housed in cubicles which should have similar notices and safety equipment within the immediate vicinity. Natural ventilation by louvres is generally sufficient for normal float charge but forced venting or a door open inter-lock should be incorporated for commissioning or boost charging.

6. VENTILATION REQUIREMENTS

It is important to adequately ventilate battery rooms and battery cabinets to remove explosive gasses, any corrosive fumes, and prevent an excessive build up of heat that may be generated during commission or boost charging.

Under normal float charge conditions relatively small amounts of hydrogen and oxygen are evolved. However, battery room ventilation should be designed to cater for all contingencies. Maximum amounts of hydrogen and oxygen will be given off when the battery is fully charged and all the available charging current is overcharging the battery.

These conditions will only occur during commissioning or when excessive boost voltage is applied resulting in maximum charging current flowing.

The volumes of hydrogen and oxygen emitted per cell can be calculated as stated below:-

(i) $H = 0.416 \times A$.

(ii) $O = 0.209 \times A$.

Where

H = volume of hydrogen per cell per hour, in litres

O = volume of oxygen per cell per hour, in litres

A = charge current, in amperes

An explosive atmosphere is created if the concentration of hydrogen in air exceeds 4% by volume. No explosion can occur without an ignition source. It is recommended that the average hydrogen concentration within the battery room should not exceed 1%, except in the immediate vicinity of the cells tops. The recommended number of air changes per hour is given by the following formula:-

Air changes per hour = (0.045 x N x A) / V

N = Number of cells in the battery
A = Charge current, in amperes
V = Volume of air in the room in cubic metres

Example:-

55 cells being charged at a constant current of 70 amperes in a room having a <u>free</u> volume of 45 cubic metres.

Air changes per hour = (0.045 x 55 x 70) / 45 = <u>3.85</u>, i.e. <u>4</u>

It should be remembered that during commissioning it is necessary to charge at a constant current until all cells are fully charged. It is under these conditions that the greatest risk of an explosion exists and sufficient ventilation must be provided to maintain the hydrogen concentration below the critical level. Remember also that an explosion cannot occur without an ignition source but recently installed batteries are at greater risk if not properly installed. A loose connection can easily cause a spark and ignite the higher concentration of gas that will inevitably be present immediately above the cells. Check all cell or monobloc and battery connections before charging the battery.

7. INSTALLATION INSTRUCTIONS

A list of tools and protective clothing is given in Section 19.

7.1 Installation of Battery Stands

Assemble the battery stand in accordance with the instructions provided with the stand and position them in accordance with the layout drawing (if provided as part of the contract) or to the Site Engineer's instructions. The following points must be observed.

1. Ensure that all the stand feet are in contact with the floor and that the stand is level, stable and does not rock. Standard steel stands are provided with adjustable plastic feet. Wooden stands will require shimming. It is important to follow the stand assembly instructions precisely, these are provided with the stand, particular attention must be made to the locking nut and washer fitted to adjustable feet of steel stands. This nut along with the washer must be "tightened" to support the stand leg. Special stands have alternative methods for levelling, e.g. shims.

2. Where two or more stands are supplied, ensure that the runners of adjacent stands are adjusted to the same height, when loaded.

3. Fit stand to wall or floor fixings as required - see stand instruction sheet.

4. Ensure that all nuts and bolts are tight and that the assembly is firm and does not rock.

7.2 Installation of Cells and Monoblocs

The cells or monoblocs must be carefully handled and "shock" loading must be avoided. They **MUST NOT** be handled in any way by the terminals, this includes lifting or positioning.

If the battery has been supplied dry, it may be better to fill the cells or monoblocs with acid before fitting them to the stand. However, it must be remembered that filled cells present a greater hazard, and there is a maximum stand time of 18 hours between filling cells and charging.

Before filling or installation, all cells or monoblocs (units) must have their terminals carefully cleaned with a "soft" brass wire brush to remove any deposits of oxide formed during storage and all exposed metal parts must again be liberally coated with the no-oxide grease supplied. This also applies to both plated and non plated accessories, take care not to remove any plating. Extra care must be taken when cleaning the terminals of filled and charged cells to avoid shorting out.

Carefully clean each unit with a soft clean cloth, do not use solvents, paraffin or other similar cleaning agents.

It is very important to liberally coat all exposed metal parts of terminal pillars with the no-oxide grease provided. Ensure that surplus grease does not come into contact with the container or lid, but it should come into contact with the identification disc and make a "seal" between the lead pillar and plastic disc. Under no circumstances should any other type of grease be used without the written approval of the company. This procedure must be carried out before filling units that have been supplied dry. See Section 3, Storage, for details of the special requirements for greasing of HCP, TPC and TPCC types, which must be carried out prior to storage or if not stored prior to or during installation.

Similarly, liberally coat the inter-unit connectors with no-oxide grease prior to installation.

Carefully position each cell or monobloc on the stand or in the cabinet avoiding unnecessary shock loadings. They must not be lifted or manoeuvred into position by the terminals. Lifting or manoeuvring by the terminals will damage the pillar seal and/or lid to container seal and will lead to premature failure. Ensure that the units sit firm and square on the stand runner or shelf.

Determine the positive and negative battery take off position and commence assembly from either of these positions. For normal series connection commencing from the positive end, cell number 1, ensure that the negative terminal of one unit is connected to the positive terminal of the adjacent unit and so on through the battery.

It is good practice to omit initially the occasional inter-unit connector and thus limit the battery voltage to safe levels whilst it is being worked on. Section 18, Isolating Connections for High Voltage Batteries, details the recommended positions and Section 7.5 gives special instructions for these batteries. These connections should only be fitted with the load isolated and when the rest of the installation is completed and checked.

When fitting connectors constructed from insulated copper bar, the insulation covers may need to be fitted to the connector before fitting to the unit.

Using an insulated torque spanner, tighten all bolts or nuts to the value stated in Section 17, Torque Settings. Exceeding the stated torque values may damage or break the screw threads, leading to an unsafe installation and unserviceable cell or monobloc. Alternatively, the cell pillar may be distorted again leading to an unsafe installation and unserviceable cell or monobloc. Re check all units to ensure that they sit firm and square on the runner or shelf.

The resistance between each connector or battery take off and unit pillar, when measured using a micro-ohm meter must be less than 25 micro-ohms this is critical on high current applications, such as UPS batteries. Failure to observe this can lead to permanent damage.

7.3 <u>Battery Take Off Connections</u>

To prevent damage to the unit pillar seal, large unsupported cables must not be terminated directly onto the pillars.

Terminal take off plates and transition boxes to suit all applications are available.

Note: When connecting the charging equipment, ensure that the positive (+) terminal of the battery is connected to the positive (+) terminal of the charger. Similarly for the negative (-), i.e. negative (-) of battery to negative (-) of charger.

7.4 <u>Insulation Covers</u>

When the terminal assembly is secure and liberally coated with no-oxide grease, fit the insulated terminal connection covers if supplied.

7.5 <u>Installation of High Voltage Batteries</u>

A battery consisting of 60 or more cells connected in series presents additional hazards and the following notes on installation should be employed.

1. When installing or working on a high voltage battery, it is essential to limit the battery voltage by omitting selected inter-unit connectors to give a maximum section voltage of 120V or 60 cells.

2. Section 18, Isolation Connectors for High Voltage Batteries, gives details of the recommended isolation connector position. The connection should be chosen to be in an accessible position. These connectors should only be fitted with the load and charger isolated and when the rest of the installation is complete and checked.

3. Never work alone on high voltage batteries. Refer to the Health and Safety At Work Act requirements or other legislation.

4. Always use insulated tools and wear approved high voltage insulating gloves.

5. When supplied, fit the "High Voltage Battery" warning labels in a prominent position.

8. FILLING WITH ACID

Where units have been supplied filled with acid from the factory, this section can be ignored.

Where units have been supplied dry, first clean and grease the pillars as detailed in Section 7.2. This will protect the pillar if acid is spilled during the filling process. Then fill with pure, cool, dilute sulphuric acid of accumulator quality complying with BS 3031: 1972 or equivalent, see Section 23. Any other type of acid will invalidate your guarantee and may cause the battery not to perform to specification or have a reduced life. Acid supplied by the Company, complies with BS 3031: 1972. It is important that cells are filled and allowed to stand for a **MINIMUM OF 4 HOURS AND A MAXIMUM OF 18 HOURS** before commencing the commissioning charge. Failure to observe this procedure can cause a permanent loss of capacity or reduced battery life. Therefore, do not fill any cells without first ensuring that the charging equipment is functioning correctly and can be charged as a complete battery. If the battery has to be split into sections for commission charging, only fill cells or monoblocs that can be fully commissioned at one time. See Section 10, Commissioning and Boost Charge, for full details.

Refer to Table 8.1 below, for the appropriate Initial Filling Gravities.

Table 8.1

Initial Filling Electrolyte Specific Gravity for Dry Charged Product

CELL TYPE RANGE	S.G. AT 20°C	S.G. AT 25°C
HAP & HBS/HBP	1.197	1.193
HCP	1.167	1.163
UHBP	1.227	1.223
TPA, TPB & TPC (High Gravity)	1.257	1.253
TPA, TPB & TPC (Low Gravity)	1.209	1.205
6MT	1.257	1.253

Carefully fill each cell to the maximum level. Any spillage should be dealt with immediately. If the units have not been positioned on the stand or in the cabinet, now is the time to do so. During the 4 to 18 hour stand period the electrolyte level will fall slightly. This is normal and the level must be restored to within 5mm of the maximum before commencing the charge. Use acid of the same specific gravity as initial filling for this topping up procedure.

Note: Some companies refer to "relative density" expressed as kilograms per cubic metre in place of specific gravity, i.e. specific gravity 1.215 = 1215kg/cum.

9. GENERAL BATTERY CHARGING REQUIREMENTS

Before charging the battery, ensure that any transit plugs are changed for service vents. Some battery types have a thin plastic film fitted under the standard vent plug to reduce acid splashing in transit, ensure that this is removed before charging. The standard vent or optional flame retardant vent must be securely fitted before charging.

Before the battery can be put into service it must receive a commissioning charge as detailed in Section 10. Failure to carry out this procedure can cause permanent damage or a reduction in service life. Full details of the commissioning charge must be recorded in the Commissioning Record Section of this manual and made available to our company if requested.

The charging system must be capable of providing a steady voltage within ± 1%V. The current available to the battery must be not less than the value given in Table 9.1 below. The maximum output from the charger need not be limited providing the cell maximum voltage does not exceed 2.25V. For economic reasons, the maximum charging current is generally specified as 8% of the 3 hour capacity.

Charger output or load induced current ripple can cause permanent damage and a reduction in battery life. The RMS limit is 7% in amperes of the 3 hour capacity over the frequency range 100 to 360Hz. For details at other frequencies, contact our company. The 3 hour capacity is given in the following Tables 9.1 - 9.6.

Table 9.1

Recommended Charge Rates, Nominal Capacities & Electrolyte Quantity

HIGH PERFORMANCE PLANTÉ				
Cell Type	**Charge Rate (amperes) Below 32°C**	**Charge Rate (amperes) Above 32°C**	**Capacity * (AH)**	**Electrolyte (litres)**
HAP5	1.3	1.0	15.2	0.93
HAP9	2.7	2.1	30.4	1.45
HAP13	4.0	3.1	45.6	2.75
HAP17	5.4	4.2	60.8	2.50

* The capacity given is in ampere hours at the 3 hour rate at 20°C to 1.80Vpc and for high gravity acid for TPA(C), TPB(C) and TPC(C) types.

Table 9.1 is continued overleaf.

Table 9.1 continued

HIGH PERFORMANCE PLANTÉ				
Cell Type	**Charge Rate (amperes) Below 32°C**	**Charge Rate (amperes) Above 32°C**	**Capacity * (AH)**	**Electrolyte (Litres)**
HBS7 & HBP7	6.0	4.6	63	3.60
HBS9 & HBP9	8.0	6.2	84	3.30
HBS11 & HBP11	10	7.7	105	4.80
HBS13 & HBP13	12	9.2	126	4.50
HBS15 & HBP15	14	11	147	6.00
HBS17 & HBP17	16	12	168	5.70
HBS19 & HBP19	18	14	189	7.20
HBS21 & HBP21	20	15	210	7.00
HBS23 & HBP23	22	17	231	8.40
HBS25 & HBP25	24	19	252	8.00
HBS27 & HBP27	26	20	273	11.5
HBS29 & HBP29	28	22	294	11.1
HBS31 & HBP31	30	23	315	10.7
HBS33 & HBP33	32	25	336	10.5
HBS35 & HBP35	34	26	357	10.4
HBS37 & HBP37	36	28	378	10.0
HCP11	39	30	416	29
HCP13	47	36	499	28
HCP15	55	42	582	35
HCP17	62	48	665	34
HCP19	70	54	748	33
HCP21	78	60	831	40
HCP23	86	66	914	38
HCP25	94	72	997	45
HCP27	101	78	1080	43
HCP29	109	84	1163	42
HCP31	117	90	1247	52
HCP33	125	96	1330	50
HCP35	133	102	1413	49
HCP37	140	108	1496	64
HCP39	148	114	1579	62
HCP41	156	120	1662	60
HCP43	164	126	1745	59
HCP45	172	132	1828	58

* The capacity given is in ampere hours at the 3 hour rate at 20°C to 1.80Vpc and for high gravity acid for TPA(C), TPB(C) and TPC(C) types.

Table 9.1 is continued on Page 17.

Table 9.1 continued

ULTRA HIGH PERFORMANCE PLANTÉ				
Cell Type	**Charge Rate (amperes) Below 32°C**	**Charge Rate (amperes) Above 32°C**	**Capacity * (AH)**	**Electrolyte (litres)**
UHBP6	7.8	6	102	3.4
UHBP7	9.1	7	119	3.2
UHBP9	12	9	153	4.6
UHBP10	13	10	170	4.4
UHBP12	16	12	204	5.9
UHBP13	17	13	221	5.6
UHBP15	20	15	255	6.0
UHBP16	21	16	272	5.8
UHBP18	23	18	306	7.6
UHBP19	25	19	323	7.4
UHBP22	29	22	374	10.5
UHBP24	31	24	408	8.9
UHBP25	33	25	425	8.7
PASTED PLATE TPA(C)				
Cell Type	**Charge Rate (amperes) Below 32°C**	**Charge Rate (amperes) Above 32°C**	**Capacity * (AH) (High sg)**	**Electrolyte (litres)**
TPA(C)5	1.2	0.9	14	1.0
TPA(C)9	2.4	1.8	28	0.9
TPA(C)13	3.7	2.8	41	1.6
TPA(C)17	4.9	3.8	55	1.4
TPA(C)21	6.1	4.7	69	2.9
TPA(C)25	7.3	5.6	83	2.7
TPA(C)33	9.8	7.5	110	2.2

* The capacity given is in ampere hours at the 3 hour rate at 20°C to 1.80Vpc and for high gravity acid for TPA(C), TPB(C) and TPC(C) types.

Table 9.1 is continued overleaf.

Table 9.1 continued

PASTED PLATE TPB(C)				
Cell Type	**Charge Rate (amperes) Below 32°C**	**Charge Rate (amperes) Above 32°C**	**Capacity * (AH) (High sg)**	**Electrolyte (litres)**
TPB(C)17	13	10	145	3.6
TPB(C)19	15	11	163	3.5
TPB(C)21	16	13	181	5.0
TPB(C)23	18	14	200	4.9
TPB(C)25	20	15	218	4.8
TPB(C)27	21	16	236	4.7
TPB(C)29	23	18	254	6.4
TPB(C)31	25	19	272	6.0
TPB(C)33	26	20	290	5.7
TPB(C)35	28	21	309	8.0
TPB(C)37	29	23	327	7.8
TPB(C)39	31	24	345	7.7
TPB(C)41	33	25	363	7.6
TPB(C)43	34	26	381	9.1
TPB(C)45	36	28	400	8.9
TPB(C)47	38	29	417	8.7
TPB(C)49	39	30	436	8.5
TPB(C)51	41	31	454	11.8
TPB(C)53	42	33	472	11.6
TPB(C)55	44	34	490	11.4
TPB(C)57	46	35	508	11.2
TPB(C)59	47	36	526	11.0
TPB(C)61	49	38	545	10.8
TPB(C)63	51	39	563	10.6

* The capacity given is in ampere hours at the 3 hour rate at 20°C to 1.80Vpc and for high gravity acid for TPA(C), TPB(C) and TPC(C) types.

Table 9.1 is continued on Page 19.

Table 9.1 continued

PASTED PLATE TPC(C)				
Cell Type	**Charge Rate (amperes) Below 32°C**	**Charge Rate (amperes) Above 32°C**	**Capacity * (AH) (High sg)**	**Electrolyte (litres)**
TPC(C)15	32	24	715	30
TPC(C)17	36	28	817	29
TPC(C)19	41	31	919	28
TPC(C)21	45	35	1022	27
TPC(C)23	50	38	1124	26
TPC(C)25	54	42	1226	36
TPC(C)27	59	45	1328	35
TPC(C)29	63	49	1430	34
TPC(C)31	68	52	1532	42
TPC(C)33	72	55	1635	41
TPC(C)35	77	59	1737	40
TPC(C)37	81	62	1839	48
TPC(C)39	86	66	1941	47
TPC(C)41	90	69	2043	46
TPC(C)43	95	73	2145	59
TPC(C)45	99	76	2248	58
TPC(C)47	104	80	2350	57
TPC(C)49	108	83	2452	56
TPC(C)51	113	87	2554	64
TPC(C)53	117	90	2656	63
TPC(C)55	123	94	2758	62
TPC(C)57	127	98	2861	61
TPC(C)59	132	101	2963	60
TPC(C)61	135	104	3065	59

* The capacity given is in ampere hours at the 3 hour rate at 20°C to 1.80Vpc and for high gravity acid for TPA(C), TPB(C) and TPC(C) types.

Table 9.1 is continued overleaf.

Table 9.1 continued

PASTED PLATE 6MT				
Cell Type	**Charge Rate (amperes) Below 32°C**	**Charge Rate (amperes) Above 32°C**	**Capacity * (AH) (High sg)**	**Electrolyte (litres)**
6MT(C)2	2.2	1.7	25	2.6
6MT(C)3	3.3	2.5	37	2.3
6MT(C)4	4.4	3.3	49	4.3
6MT(C)5	5.5	4.2	62	4.2
6MT(C)6	6.5	5.2	74	4.1
6MT(C)7	7.6	6.0	87	7.4
6MT(C)8	8.7	6.9	99	7.1
6MT(C)9	9.8	7.7	111	6.8

* The capacity given is in ampere hours at the 3 hour rate at 20°C to 1.80Vpc and for high gravity acid for TPA(C), TPB(C) and TPC(C) types.

10. COMMISSIONING AND BOOST CHARGE

10.1 Commissioning Charge - General Requirements

Throughout the commissioning (start up) charge the electrolyte level must be maintained between the maximum and minimum lines printed on the cell container by adding purified water to the specification given in Section 22. However, during charging the electrolyte level may increase up to 5mm over the maximum line permitted when the cells are gassing freely at top of charge.

Throughout the charge, the electrolyte temperature, as measured at the pilot cells, must not be allowed to exceed 40°C. If this temperature is reached, the charge must be terminated, the battery allowed to cool until the electrolyte temperature reduces to 35°C, or below, before continuing the charge. Failure to observe the maximum temperature can cause permanent damage and/or a reduction in battery life.

The specific gravity and electrolyte temperature of the pilot cells should be recorded at hourly intervals throughout the charge. The pilot cell should be chosen to indicate the maximum temperature of a group of not more than 30 cells, e.g. for a 204 cell battery, 7 pilot cells are required.

At the end of the commissioning charge, the specific gravity and voltage of **ALL** cells must be recorded along with the temperature of the electrolyte of the pilot cells. These recordings must be taken at hourly intervals over a 2 or 3 hour period, i.e. 3 or 4 sets of readings.

The commissioning charge must be carried out at a **CONSTANT CURRENT** without voltage limit. The current used must be as given in Table 9.1 above, for the battery type being charged, with a tolerance of not more than ± 10%. However, as the cells approach the end of charge, this current must remain stable within ± 1%, e.g. if Table 9.1 indicates that the nominal charging current is 100A, then any current between 90A and 110A is acceptable. However, this current must be maintained stable, within ± 1% of the chosen value, e.g. if charging at 95A then the current must be stable between 94A and 96A. This fine stability is required to ensure the battery is fully charged and false readings are not obtained.

Because it is necessary to carry out the commissioning charge at a constant current, it must be ensured that the charging equipment is capable of raising the cell potential up to approximately 2.85 Vpc. Some charging equipment does not have this capability and it will be necessary to split the battery into two sections. Typical examples of this are UPS chargers, but not all. If this limitation is found, the battery must be charged in two sections. If this is not a limitation, it can be charged in one section.

In order to explain the charging procedure where the charging voltage is restricted, an example for a 204 cell battery is given here. The normal float voltage for a 204 cell battery is 459V across the battery terminals (2.25 Vpc). This voltage should be divided by 3 to find the maximum number of cells in each section. Figures 10.1 and 10.2 indicate the position of the charger for the alternative sections. It will be observed that the central section of the battery will be commission charged, twice. This is not detrimental but the centre section should be carefully watched to ensure the electrolyte level does not fall below the minimum line and the temperature does not exceed 40°C.

The number of cells in each section is 459V/3 = 153 cells. It will therefore be observed that with the charger in the first position, Figure 10.1, cell numbers 1 through 153 will be charged and in the second position, Figure 10.2, cells 52 through 204 will be charged. This will mean that cells 52 through 153 will receive the charge, twice.

The charger output voltage should be set at the nominal float voltage for the battery, the current should be adjusted to a low value, preferably 0 amperes. Power to the battery can then be connected and the current slowly increased until the required current is obtained.

During charging of the first section, Figure 10.1, the individual cell voltages will be seen to rise slowly up to about 2.30 Vpc where a more rapid increase up to about 2.70 Vpc will be recorded. This higher cell voltage indicates that the cells are approaching a fully charged state. Figure 10.3 shows a typical voltage against time characteristics curve. During charging the second half of the battery the centre section voltage will rise very rapidly up to about 2.70 Vpc. However, the remaining cells (numbers 154 to 204 in our 204 cell battery example) voltage will be seen to rise slowly up to about 2.30 Vpc where a more rapid increase up to about 2.70 Vpc will be recorded. Again, this higher cell voltage indicates that the remaining cells (numbers 154 to 204) are approaching a fully charged state.

If the battery and charging equipment voltage can be increased up to about 2.85 Vpc (582 volts for the 204 cell battery used as an example) then the complete battery can be charged in one operation.

If the battery charging equipment voltage can not be increased to 2.85 Vpc, but has the flexibility of being reduced, or if current control can be obtained at lower battery voltages, then it may be possible to split the battery into two equal or nearly equal sections. This will mean that there will be no centre section and the subsequent close watch of cell temperatures and frequent topping up will be avoided.

Note: Where product has been supplied dry, do not fill all the cells or monoblocs if the battery has to be charged in two sections. Remember the MAXIMUM stand time before charging is 18 hours. It may be necessary to fill only some cells or monoblocs, commission charge these and then fill and charge the remaining units.

To ensure the battery is fully charged, charging must be continued until specific gravities (corrected for temperature) and voltages of ALL cells remain constant for three consecutive hourly intervals.

Towards the end of the charge, the electrolyte level should be maintained within ± a few millimetres of the maximum line. Failure to observe this can lead to false readings being observed.

Having obtained constant readings, some adjustment of the specific gravity may be necessary. Factory processing is carried out to ensure that a gravity of not less than that required as given in Table 10.1 will be obtained. Therefore, any adjustment will involve removing acid and adding water. Section 11 gives details of this procedure.

Table 10.1

Specific Gravity of Electrolyte In Fully Charged Cells

Cell Type	Specific Gravity	
	at 20°C	at 25°C
Planté Types HAP, HBS/HBP & HCP	1.202 to 1.212	1.198 to 1.208
Ultra High Performance Planté Types UHBP	1.232 to 1.242	1.228 to 1.238
Pasted Plate Types TPA(C), TPB(C) & TPC(C) HIGH GRAVITY	1.262 to 1.272	1.258 to 1.268
Pasted Plate Types TPA(C), TPBC(C) & TPC(C) LOW GRAVITY	1.214 to 1.224	1.210 to 1.220
Pasted Plate Type 6MT	1.262 to 1.272	1.258 to 1.268

Irrespective of the time involved, the charge is not complete until constant values are observed. The precise time to complete the commissioning or boost charge depends on many factors including storage conditions, storage time, and charge current used.

Charging must be continued until all specific gravities (corrected for temperature) and unit voltages remain constant for three consecutive hourly periods.

Upon completion, the battery can be put into service or tested as required.

Note: Under extreme conditions, the commissioning charge may be carried out at a current down to half that given in Table 9.1, but not less than this. This low current may be used if the charging source is restrictive or if high temperatures are experienced. It must be noted that the commissioning charge time will be extended, e.g. at half current the time will be at least double.

10.2 Commissioning Charge For Filled and Nominally Charged Batteries

The commissioning charge for batteries supplied filled and nominally charged involves charging at the required current until constant specific gravities (corrected for temperature) and unit voltages recorded over three consecutive readings taken at hourly intervals and the gravity has been adjusted to the correct value at the maximum level.

The procedure for the charge is fully detailed above in sub section 10.1.

Ensure that you observe the general requirements throughout the charge.

10.3 Commissioning Charge For Dry Charged Batteries

After filling the cells, they must be stood for a minimum of 4 hours and a maximum of 18 hours before commencing the commissioning charge. The commissioning charge time for dry charged batteries depends on the storage time, storage temperature, storage humidity, charge current used and battery type. It is impossible to generalise but Table 10.2 below will give a guide to the **minimum** times required. If constant specific gravities and unit voltages have not been obtained after these times, continue charging.

Table 10.2

Minimum Commissioning Charge Times For Dry Charged Batteries

Cell Type	New	Time Expired
Planté Types HAP & HBS/HBP	20	40
Planté Type HCP	72	90
Ultra High Performance Planté Types UHBP	20	40
Pasted Plate Types TPA(C) & TPB(C)	20	40
Pasted Plate Types TPC(C)	40	80
Pasted Plate Type 6MT	20	40

Time Expired Dry Charged product as referred to in Section 3, STORAGE, sub-section 3.3 Cells or Monoblocs Supplied Dry Charged, will need an extended charge period. This extended charge period may be up to 2 times longer than normal and Table 10.2 gives further details. The important aspect is to keep charging until three consecutive hourly readings of all cell specific gravities and unit voltages have been recorded. If in doubt about this extended charge, contact our company for advice.

The procedure for the charge is fully detailed above in sub section 10.1.

Ensure that you observe the general charging requirements throughout the charge.

FIGURE 10·1

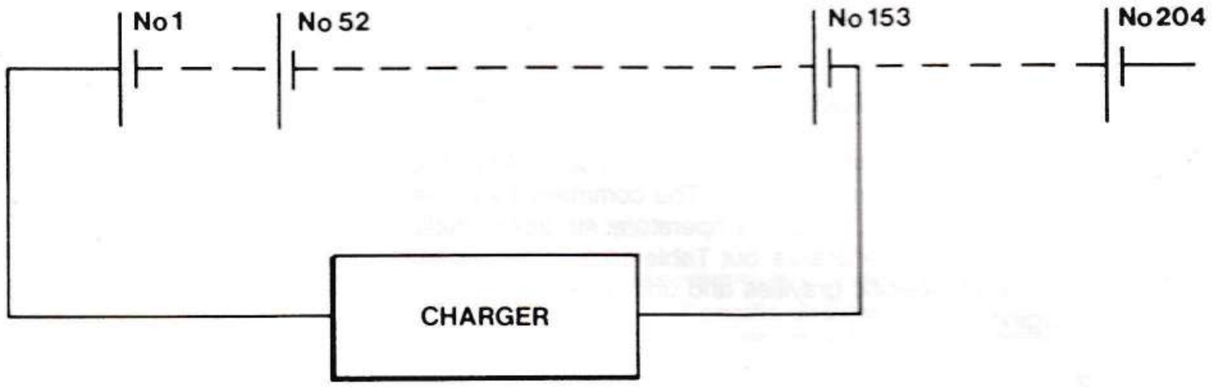


FIGURE 10·2

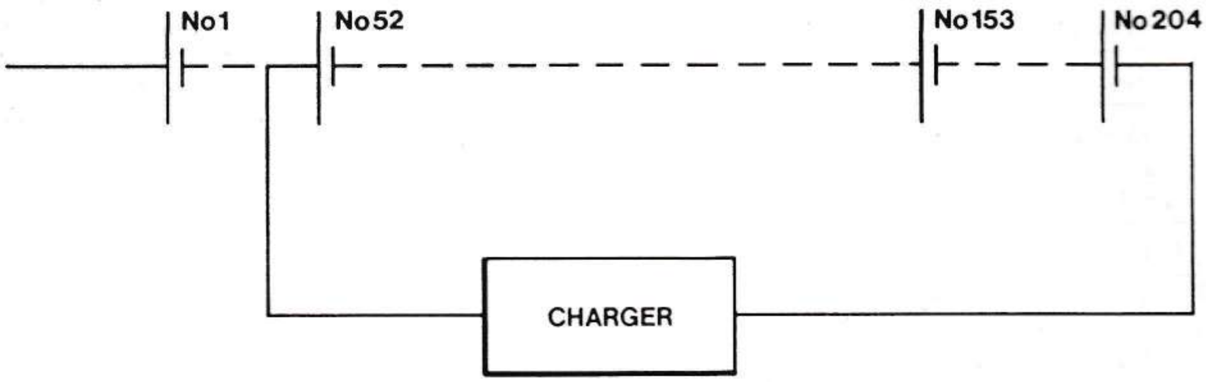
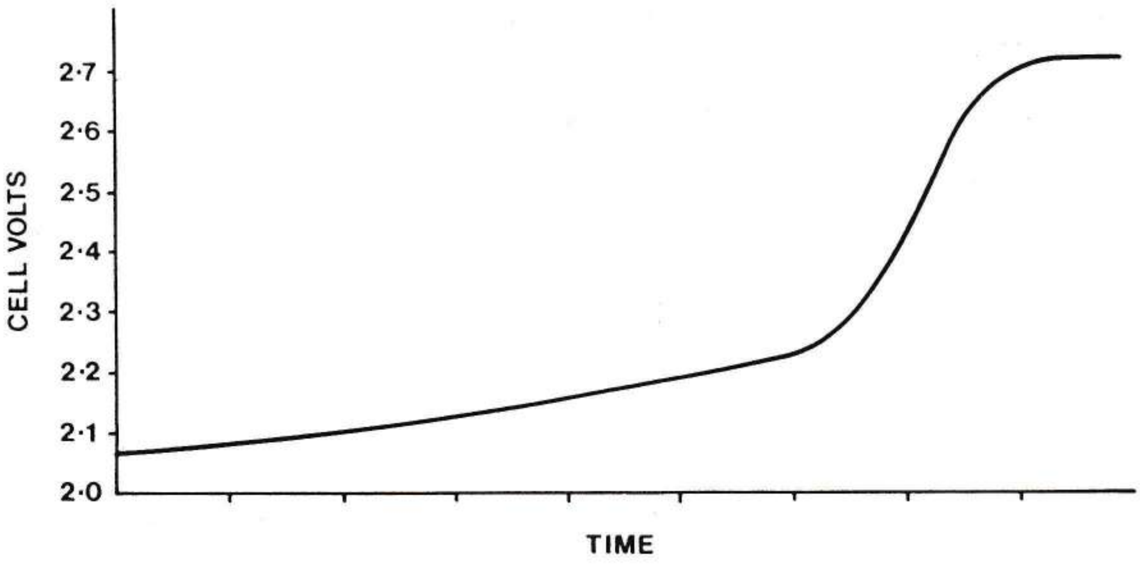


FIGURE 10·3



10.4 Commissioning Charge For Dry Formed Batteries

Dry Formed batteries are only supplied to special order. The commissioning charge should be carried out as detailed in the General Requirements, above.

Upon initial filling with acid an increase in temperature and fall in specific gravity will be observed. The cells should be stood for a minimum of 4 hours and a maximum of 16 hours. The electrolyte level will fall slightly during this time and must be adjusted to the maximum level before charging.

The charging time required is at least three times, and may be five times or more, than that required for dry charged batteries. Use the times in table 10.2 x 3, as a starting guide only. The commissioning charge for batteries supplied dry formed, involves charging at the require constant current until constant specific gravities (corrected for temperature) and the unit voltages have not increased for three consecutive hourly intervals, and the gravity has been adjusted to the correct value at the maximum level.
Ensure that you observe the general charging requirements throughout the charge.

10.5 Boost Charge or Equalising Charge

Batteries that have been commissioned and in service for some time may require a boost (equalising) charge from time to time if the specific gravity is seen to decrease. Here, if the electrolyte specific gravity, corrected for temperature and electrolyte level, is more than 10 points (0.010) below the fully charged level, a boost (equalising) charge should be given. This may occur for several reasons but is usually only experienced if a low float voltage is used. Other reasons for needing a boost charge are if the battery has been subjected to a very deep discharge or left without a charge for some time such as during storage. The boost charge should ideally be carried out as given above in sub-section 10.2 Commissioning Charge For Filled and Nominally Charged Batteries.

Practical constraints may limit the maximum boost (equalising) voltage to 2.50Vpc or even less. These systems are acceptable but recharge times may be extended.
Contact the company for further advice.

11. ADJUSTMENT OF SPECIFIC GRAVITY

At the end of the commissioning charge, the specific gravity of electrolyte of all cells must be adjusted to the value given in Table 10.1. The electrolyte level must be at the maximum level before making any adjustments.

The specific gravity of the electrolyte varies with temperature and any readings observed on a hydrometer or densimeter must be corrected to be meaningful. For each 1.5°C by which the electrolyte temperature exceeds 20°C add 1 point (0.001) to the specific gravity as read. For each 1.5°C below, subtract 1 point (0.001) from the specific gravity as read.

Generally, if any adjustment is needed, it will be because the gravity is high. As a guide, first remove some electrolyte from the cell and add purified water to the specification in Section 22, for every 5ml of water added, per litre of electrolyte in the cell, the final gravity will be one point (0.001) lower, e.g. if a UHBP15 cell has an sg of 1.250 at 20°C it must be reduced by 8 to 18 points to obtain 1.232 to 1.242 as given in Table 10.1. The UHBP15 has an electrolyte volume of 6 litres, from Table 9.1. Therefore, first remove 5ml x 6 x 13 = 390ml, then add 390ml of purified water. Note we use 13 because it is mid way between 8 and 18 points. Further adjustment may be required after a short mixing charge at the standard charge rate as given in Table 9.4, for 15 to 45 minutes.

It is unlikely that the finished sg will be low. However, if it is and you are sure the cell is fully charged, strong acid must be added. Using the same principal as above, for every 6ml of 1.400sg acid added, per litre of electrolyte in the cell, the final gravity will be one point (0.001) higher. Further adjustment may be required after a short mixing charge at the standard charge rate as given in Table 9.4, for 15 to 45 minutes.

12. SITE ACCEPTANCE TESTING PROCEDURE

If the battery is to be subjected to site acceptance test before going into service, it must first receive a commissioning charge as detailed in Section 10 to ensure it is fully charged. The battery may then be put on float charge as detailed in Section 13 and the test may then be carried out. If the battery has been commission charged and been on normal float charge for some time it must be established that the battery is fully charged before the test is started. By referring to historical battery records and the specific gravities of the electrolyte, it is possible to establish if the battery is fully charged. A lower specific gravity than that recorded previously indicates that the battery is not fully charged and it must be given a Boost Charge as detailed in Section 10.

Before the test, measure and record individual cell specific gravities and electrolyte temperature, cell or monobloc float voltages, overall battery voltage and charging current. Check all connections are clean and check all torque values immediately before testing any battery, even if this was carried out at the installation stage.

The maximum period between the end of the float period and the beginning of the test, must not exceed 24 hours. In practice, it is best to "fail" the charger input and allow the battery to discharge as intended in service. Alternatively, it is acceptable to test the battery following the commissioning charge, without going to the float charge stage, providing the test is started not more than 24 hours after the completion of the commissioning charge.

12.1 Variation in Discharge Time with Temperature for High Performance Planté Cells & Pasted Plate Cells

The test should be carried out in general accordance with BS 6290 Part 1, 1983.

It should be noted that the battery temperature will affect its discharge performance. The variations are given in Table 12.1 below.

Table 12.1

Length of Discharge	0°C	5°C	10°C	15°C	20°C	25°C	30°C	35°C	40°C
1 Second to 59 Mins	0.70	0.775	0.85	0.925	1	1.075	1.15	1.225	1.30
1 Hour to 24 Hours	0.80	0.85	0.90	0.95	1	1.05	1.10	1.15	1.20

13. FLOAT CHARGE VOLTAGE

The recommended float voltage for the Company's Vented Lead Acid Batteries is 2.25 Vpc. This voltage is applicable for all temperatures within the range 10°C to 30°C. For temperatures outside this range, the Company should be contacted for advice.

Operating the battery at an annual mean electrolyte temperature of over 20°C will cause a reduction in service life.

Many companies operate at a float voltage lower than that recommended above which will reduce water loss due to electrolysis and enhance battery life in high ambient temperatures. Although the float voltage may be reduced, it is the Company's recommendation that a float voltage of less than 2.15 Vpc is not used. If a float voltage below 2.25 Vpc is used, it will be necessary to boost charge (equalise charge) the battery as detailed in Section 10 at regular intervals to keep it healthy. In this respect, the boost charge should be carried out if the electrolyte specific gravity of any cell falls by more than 0.010 below the normal fully charged value.

Failure to boost charge the battery at the prescribed intervals, in accordance with Section 10, can lead to acid stratification and rapid plate deterioration which will significantly effect the performance and service life of the battery.

14. LOW VOLTAGE DISCONNECT

It is recommended that a low voltage disconnect feature is included in the system to operate at a minimum average voltage of 1.60 Vpc to prevent the possibility of permanent damage and reduction of service life. A momentary dip in voltage below 1.60 Vpc, such as would occur during switch closing or for engine starting duties is not detrimental.

Batteries must not be left in a discharged or partially discharged condition after supplying the load but must be recharged fully as soon as possible by either giving a boost charge as detailed in Section 10, or putting back on to float charge as detailed in Section 13. Where low float voltages are used a boost recharge must be given.

Failure to observe these important instructions may result in greatly reduced service life, reliability and permanent damage.

15. PARALLEL STRING BATTERIES

Cells or monoblocs of the same type and ampere hour rating may be connected in parallel to give higher ampere hour capacities. Up to four parallel strings may be used without special precautions, other than to ensure that the connectors are designed such that the current is distributed equally between each string. Contact the company for advice if more than four parallel strings are required.

16. SERVICE INSTRUCTIONS

A standby battery is often the last line of defence in situations when the normal power supply is lost. Accordingly, service of the equipment must reflect the importance of having a back up battery. If, at any time, an abnormal condition is observed, make a note along with readings of voltage, specific gravity and temperature, then establish the cause of the abnormality and rectify it, without delay.

When topping up cells it is imperative that only purified water to the specification in Section 22 is used. Also, it is recommended that cells are topped up before the level of electrolyte is allowed to fall to the minimum line. If the level is allowed to fall to the minimum before topping up, it may lead to stratification of the electrolyte, particularly when a low float voltage is used. In cases of low float voltage or if stratification is suspected, the battery should be given a boost charge, as detailed in Section 10, after topping up until the electrolyte is thoroughly mixed. Unless the cell is actually being topped up, the service vent must be fitted at all times.

Note: When cells are equipped with anti-explosion vents it is not necessary to remove the vents to measure temperature or specific gravity or to add water to the cell.

16.1 Initial Records

At the commissioning stage it is important to measure and record in Section 24 of this manual, individual cell specific gravities, temperature and cell or monobloc voltages. Refer to Section 10 for further details. The readings taken at the commissioning stage form the basis of all future readings.

After completing the commissioning charge and ideally immediately after connecting to the normal float charge voltage, ensure that the battery charging voltage is within the recommended limits for the system and the float voltage is correct for the battery temperature as detailed in Section 13. Measure and record in Section 24 of this manual, all cell or monobloc voltages, pilot cell specific gravities and temperature, and charge current. A pilot cell is used to give an approximation for the battery as a whole and several pilot cells should be chosen. Batteries consisting of monoblocs will need pilot monoblocs not pilot cells. For batteries of 24 cells or less, two pilot cells or monoblocs should be chosen. For larger batteries, a pilot cell or monobloc every 20 cells is sufficient.

If a site acceptance test is to be carried out, refer to Section 12 for further details.

16.2 Monthly Inspection

Ensure that the battery charging voltage is within the recommended limits for the system and the float charge voltage is correct for the battery temperature as detailed in Section 13.

16.3 First Three Month Service

Ensure that the battery charging voltage is within the recommended limits for the system and the float charge voltage is correct for the battery temperature as detailed in Section 13.

With the charging system connected and battery is in its normal mode of operation, measure and record in Section 24 of this manual, all cell specific gravities and temperatures, all cell or monobloc voltages and charging current.

Check and top up cells as required with purified water to the specification as given in Section 22.

16.4 **Normal Three Month Service**

Ensure that the battery charging voltage is within the recommended limits for the system and the float charge voltage is correct for the battery temperature as detailed in Section 13.

With the charging system connected and the battery in its normal mode of operation, measure the pilot cell or monobloc voltages, specific gravities and temperature. If the readings are normal these need not be recorded, however if they are not normal, measure and record in Section 24 of this manual **ALL** cell specific gravities and temperatures, **ALL** cell or monobloc voltages and charging current. Establish the cause of the abnormality and rectify.

Check and top up all cells as required with purified water to the specification as given in Section 22.

16.5 **Six Monthly Service**

With the charging system connected and the battery in its normal mode of operation, measure and record in Section 24 of this manual, all cell specific gravities and temperatures, all cell or monobloc voltages and charging current.

Check battery and cell or monobloc connections for correct torque tightness as detailed in Section 17.

Check and top up all cells as required with purified water to the specification as given in Section 22.

Keep connectors and terminals clean and well coated with no-oxide grease to prevent corrosion. Further supplies of no-oxide grease are available.

Carry out a thorough visual inspection of the battery and record any abnormalities. Establish the cause of the abnormality and rectify.

16.6 **Extended Period Servicing**

When the monthly checks have shown that the battery and charging system are operating correctly, the interval between these checks can be extended to three months. However, this should not be done for the first six months.

Similarly, the Normal Three Month Service may be extended to six months and the Six Month Service to Annual, providing the battery has shown to be operating satisfactorily.

16.7 **Cell and Monobloc Cleanliness**

Ensure that the cells and monoblocs are at all times clean and dry. Any water or acid spillages should be cleaned up immediately. Containers and lids must only be cleaned with a cotton cloth dampened with clean water or a solution of soapy water. DO NOT USE SOLVENTS, PARAFFIN OR OTHER SIMILAR CLEANING AGENTS.

17. TORQUE SETTINGS

Table 17.1

CELL TYPE RANGE	RECOMMENDED TORQUE VALUE		
	Nm	KG fm	lbf FT
HAP	5	0.51	3.7
HBP (bolt and nut connections)	7	0.72	5.2
HBS (threaded stud connections)	16	1.63	11.8
HCP	25	2.55	18.4
UHBP	16	1.63	11.8
6MT2 & 3	5	0.51	3.7
TPA(C)	5	0.51	3.7
6MT4-9	7	0.72	5.2
TPB(C)	16	1.63	11.8
TPC(C)	25	2.55	18.4

18. ISOLATION CONNECTORS FOR HIGH VOLTAGE BATTERIES

Section 7.5, Installation of High Voltage Batteries explains the additional hazard and appropriate precautions that **must** be employed when working on batteries greater than 120V or 60 cells. Before other work is performed it is essential that isolating connectors, as detailed in Tables 18.1 and 18.2, are removed to ensure the battery is broken into sections of less than 120V or 60 cells. Similarly, during installation these connectors should only be fitted after all other work on the battery has been completed. The exact position of each isolating connector is not critical but the maximum number of units in each section should not exceed 60 cells, or 20 six volt monoblocs. When supplied, fit the isolation link labels and the "High Voltage Battery" warning labels in a prominent position.

FOR SAFETY'S SAKE! DO NOT WORK ALONE ON BATTERIES WITH A VOLTAGE OF 120V OR MORE.

Table 18.1

Suggested Position of Isolating Connectors for High Voltage Batteries Made Up of Individual Cells

No of Cells	Sections	Section 1	Section 2	Section 3	Section 4
1-24	1				
25-99	2	49-50			
100-109	3	35-40	75-80		
110-119	3	35-40	75-80		
120-129	3	40-45	80-85		
130-139	3	45-50	85-90		
140-149	4	30-35	70-75	105-115	
150-159	4	35-40	75-80	115-120	
160-169	4	40-45	80-85	120-125	
170-179	4	40-45	85-90	130-135	
180-189	4	45-50	90-95	135-144	
190-199	5	35-40	75-80	115-120	155-160
200-209	5	40-45	80-85	120-125	160-165
210-220	5	40-45	85-90	130-135	170-175

Table 18.2

Suggested Position of Isolating Connectors for High Voltage Batteries Made Up of 6 Volt Monoblocs

No of Monoblocs	Sections	Section 1	Section 2	Section 3	Section 4
1-8	1				
9-29	2	13-16			
30-36	3	12-13	24-25		
37-42	3	14-15	28-29		
43-48	3	16-17	30-31		
49-54	4	14-15	28-29	42-43	
47-60	4	15-16	30-31	45-46	
61-66	5	12-13	24-25	36-37	48-49
67-72	5	13-14	26-27	39-40	42-43
73-78	5	16-17	31-32	46-47	62-63

19. TOOLS AND PROTECTIVE CLOTHING

The minimum tools required for the installation of your battery are listed below. The specialist tools can be obtained from our Company.

1. Insulated and Calibrated Adjustable Torque Spanner 1-25Nm or of a suitable range for the product being worked on, and sockets.
2. Set of insulated tools, spanners and socket sets:
3. Calibrated Digital voltmeter.
4. "Soft" wire brush.
5. Spirit level.
6. Socket head (Allen) keys.
7. Sharp knife.
8. Cable cutters and crimpers.
9. Hydrometer.
10. Thermometer.
11. Eye Wash Station.

Additionally

When working on lead acid batteries, the following protective items must be worn:-

Eye goggles, face screens (visors) or safety spectacles must comply with Specification BS 2092 or similar.

Protective clothing must comply with Specification BS 4170 or similar and consist of waterproof clothing made from coated fabrics complying with Specification BS 3546 or similar.

Note: Clothing manufactured from some synthetic fibres (eg nylon) generates high static electricity within an operative's body and could cause explosions through static electricity discharges when working on cells.

Rubber gloves must comply with Specification BS 1651, Appendix C, or similar.

Hard hats (safety helmets) must comply with Specification BS 5240, or similar.
Boots and rubber footwear must comply with Specification BS 5145, or similar.

These British Standard Specifications naturally relate to working within the UK, but the comparable specifications must be complied with in other countries. It is for this reason that we have added the words "or similar" after the BS reference. **It is the responsibility of the organisation installing or servicing the batteries to ensure that adequate protective items are available and are used by the operative.**

The use of the Companies installation and service engineers will ensure compliance with legislation, and also make certain that the battery is in an optimum and safe condition.

20. CUSTOMER SERVICE

It is essential that batteries are correctly maintained. Tungstone Batteries Ltd and BS 6133 recommend a comprehensive inspection every six months and a test discharge every two years, with increased frequency due to the age of the battery.

The Company operates a full installation, commissioning and battery service which we would recommend to you, particularly for high voltage installations.

As one of the largest manufacturers of standby batteries in Europe, our expert staff can provide a customised service and maintenance package.

The benefits to you are:-

- Extended warranty options available on new batteries.
- Battery condition evaluated by specialists and a full report given.
- Battery discharge test enables state of every cell to be evaluated.
- All specialist equipment provided.

Tungstone Batteries are also suppliers of state of the art battery monitors to permit constant evaluation of each cell's voltage. The monitor also permits each cell to record daily short discharges up to 30 minute rate on UPS batteries where it is not practical to manually record.

Tungstone is a registered carrier for the disposal of scrap batteries, thus ensuring that batteries are correctly disposed of in line with current legislation.

For further details of these services and a quotation, please complete the form "Request for Further Information" on page 37 of this booklet.

21. DIAGNOSIS OF BATTERY CONDITION

The following notes enable an easy assessment of the state of charge and general condition of the cells.

The following indicate a cell in a healthy charged condition:

Specific gravities all within the limits indicated in Table 10.1.
Float voltage correct - see Section 13.
Positive plates - dark brown colour.
Negative plates - metallic slate grey colour.
Gassing from cells when switched to boost charge.

The following indicates that a battery has been undercharged:-

Specific gravities low and irregular.
Unit float voltages low or irregular - see Section 13.
Positive plates are a light brown colour.
Negative plates are a non-metallic dark grey colour.
Boost charge voltage is low.
No gassing when the system is switched to boost charge.
Both positive and negative plates may be speckled.

An undercharged battery is caused by:

(i) Charge voltages and/or currents too low.
(ii) Insufficient freshening charges (current or duration).

The following indicates a battery that has been overcharged:

Specific gravities high.
Float voltages high or low.
Excess gassing on float charge.
Low electrolyte levels.
Excessive deposits of sediment in the base of cell container .
Shedding of positive plate active material.
Spongy deposit on negative plates.
Expansion and distortion of positive plates.
Excessive water consumption.

An overcharged battery results from:

(i) Excessive periods of boost charge.
(ii) Too high charging rate.
(iii) Float voltage settings too high.

If there is evidence of undercharging or overcharging, then adjust the charge rates according to the type and if necessary consult the company for further advice.

22. SPECIFICATION OF PURIFIED WATER FOR VENTED LEAD ACID CELLS

Only purified water complying with BS 4974: 1975 Grade A shall be used. This specification details the maximum permissible impurities which are outlined below.

22.1 Description

The material shall be water purified by distillation or ion exchange. It shall be clear and colourless when viewed through a depth of 300mm.

22.2 Conductivity

The material shall not have a conductivity greater than 1mS/m*, measured at 20°C, when tested by the method described in BS 4974: 1975, Appendix H.

* 1S (Siemens) = $1/\Omega$ (mho)
1mS/m = 10 μmho/cm

22.3 Manganese Content

The material shall not contain more than 0.1mg of manganese, Mn, per kilogram, determined and calculated by the method described in BS 4974: 1975, Appendix A.

22.4 Sample

For the purpose of examination in accordance with this specification, a representative sample of the material not less than 2000ml in volume shall be taken from the bulk. The sample shall be placed in a clean, dry and airtight glass stoppered bottle of borosilicate glass of such a size that it is nearly filled by the sample. If it is necessary to seal the bottle, care shall be taken to avoid contaminating the contents in any way.

22.5 Packaging and Marking

The material shall be supplied in sound, clean containers of glass, polyethylene or other suitable plastics material. Ideally, identification and marking shall mention British Standard BS 4974: 1975, and Grade A.

23. SPECIFICATION FOR FILLING ELECTROLYTE

Sulphuric acid for use in the company's lead acid batteries must be in accordance with BS 3031: 1972. This standard is outlined below.

23.1 Description

The material shall consist essentially of an aqueous solution of sulphuric acid, H_2SO_4. It shall be clear and colourless when viewed through a depth of 300mm.

23.2 Definition

Reference acid. The numerical limits in sub sections 23.5 to 23.12 are stated in relation to a reference acid of density 1.215g/ml at 20°C.

23.3 Sample

For the purpose of examination in accordance with this standard, a representative sample of the material not less than 1 litre in volume shall be taken from the bulk. The sample shall then be placed in a clean, dry and airtight glass stoppered glass bottle of such a size that it is nearly filled by the sample. When it is necessary to seal the bottle, care shall be taken to avoid contaminating the contents in any way. The volume of sample to be taken for each determination shall be calculated in accordance with BS 3031: 1972 Appendix A.

23.4 **Residue on Ignition**

The residue on ignition of the material, determined and calculated by the method described in BS 3031: 1972 Appendix B shall not exceed the equivalent of 0.015% by mass of the reference acid defined in 3.

23.5 **Chloride**

The chloride content of the material, expressed as C1, determined and calculated by the method described in BS 3031: 1972, Appendix C shall not exceed the equivalent of 7 parts per million by mass of the reference acid defined in 3.

23.6 **Sulphur Dioxide**

The sulphur dioxide content of the material, expressed as SO_2, determined and calculated by the method described in BS 3031: 1972, Appendix D, shall not exceed the equivalent of 5 parts per million by mass of the reference acid defined in 3.

23.7 **Ammoniacal Nitrogen**

The content of ammoniacal nitrogen of the material, expressed as NH_3, determined and calculated by the method described in BS 3031: 1972, Appendix E, shall not exceed the equivalent of 50 parts per million by mass of the reference acid defined in 3.

23.8 **Nitrogen Oxides**

The nitrogen oxides content of the material, expressed as N, determined and calculated by the method described in BS 3031: 1972, Appendix F, shall not exceed the equivalent of 5 parts per million by mass of the reference acid defined in 3.

23.9 **Iron**

The iron content of the material, expressed as Fe, determined and calculated by the method described in BS 3031: 1972, Appendix G, shall not exceed the equivalent of 12 parts per million by mass of the reference acid defined in 3.

23.10 **Copper**

The copper content of the material, expressed as Cu, determined and calculated by the method described in BS 3031: 1972, Appendix H, shall not exceed the equivalent of 7 parts per million by mass of the reference acid defined in 3.

23.11 **Manganese**

The manganese content of the material, expressed as Mn, determined and calculated by the method described in BS 3031: 1972, Appendix J, shall not exceed the equivalent of 0.4 parts per million by mass of the reference acid defined in 3.

23.12 **Arsenic**

The arsenic content of the material, expressed as As, determined and calculated by the method described in BS 3031: 1972, Appendix K, shall not exceed the equivalent of 2 parts per million by mass of the reference acid defined in 3.

24. BATTERY RECORD SHEETS

Several blank sheets are provided for both Commissioning & Boost Charge Records, and Service Records. Additional sheets may be copied as required, or obtained from the company.

24.1 Commissioning & Boost Charge Record Sheets

These must be completed at the time the battery is commissioned. The first reading must be taken on ALL cells immediately prior to commencing the charge. The second reading must commence within 5 minutes of the commissioning charge starting and ALL cell voltages must be recorded, along with the actual charge current. The specific gravities and cell temperatures need not be recorded at this second reading. The third recorded information should be after 1 hour of charging when the specific gravity and electrolyte temperature of the pilot cells should be taken.

The pilot cells should be chosen to indicate the maximum temperature of a group of not more than 30 cells, e.g. for a 204 cell battery, 7 pilot cells are required but irrespective of the number of cells, not less than 3 pilot cells are required, e.g. 24 cell battery must have 3 pilot cells. Subsequent pilot cell readings must be recorded at hourly intervals. At the end of the commissioning or boost charge, the specific gravity and voltage of ALL cells must be recorded along with the temperature of the electrolyte of the pilot cells. These recordings must be taken at hourly intervals over a 2 or 3 hour period, i.e. 3 or 4 sets of readings.

An example of a completed Record Sheet is shown below:-

Commissioning and Boost Charge Record Sheet

This Record Sheet must be completed during commission and boost charging.

Tungstone W.O. No	F1574-39		
Customer Ref	TB/CB1		
No. of Cells/Monoblocs	24	Type HCP41	Date Installed 18 JAN 93
Installed At	ELECTRIC POWER STATION	Battery Title CRITICAL BATTERY Nº 1	
Charge Current (see Table 9.1)	156 A	Date of Charge 19 JAN 93	
Comments:	Page 1 of 2 - Boost Charge		
Engineer in Charge	ENGINEER A.N. ELECTRIC		

	Time - 0800 HRS			Time - 0830 HRS			Time - 0900 HRS			Time - 1000 HRS			Time - 1100 HRS		
	Amps - OPEN CIRCUIT			Amps - 156			Amps - 156			Amps - 158			Amps - 154		
Cell No	Volts V	Specific Gravity	Electrolyte Temp °C	Volts V	Specific Gravity	Electrolyte Temp °C	Volts V	Specific Gravity	Electrolyte Temp °C	Volts V	Specific Gravity	Electrolyte Temp °C	Volts V	Specific Gravity	Electrolyte Temp °C
1	2.04	1.190	18	2.12	1.190	18	2.13	1.190	18	2.16	1.192	19	2.61	1.196	20
2	2.04	1.192	18	2.12	1.192	18	2.13	1.192	18	2.16	1.194	19	2.60	1.197	20
3	2.04	1.190	18	2.12	1.190	18	2.13	1.192	18	2.16	1.195	19	2.60	1.197	20
4	2.04	1.192	18	2.12	1.192	18	2.13	1.194	18	2.16	1.194	19	2.60	1.197	20
5	2.04	1.192	18	2.12	1.192	18	2.13	1.194	18	2.16	1.194	19	2.61	1.197	20
6	2.04	1.192	18	2.11	1.192	18	2.13	1.192	18	2.17	1.194	19	2.61	1.197	20
7	2.04	1.190	18	2.12	1.190	18	2.13	1.190	18	2.16	1.194	19	2.60	1.195	20
8	2.04	1.192	18	2.12	1.192	18	2.13	1.192	18	2.16	1.194	19	2.60	1.195	20
9	2.04	1.190	18	2.11	1.190	18	2.13	1.190	18	2.17	1.194	19	2.61	1.197	20
10	2.04	1.190	18	2.12	1.190	18	2.13	1.192	18	2.17	1.194	19	2.62	1.197	20
11	2.04	1.190	18	2.12	1.190	18	2.13	1.190	18	2.17	1.194	19	2.62	1.197	20
12	2.04	1.190	18	2.13	1.190	18	2.13	1.192	18	2.16	1.192	19	2.62	1.195	20
13	2.04	1.192	18	2.12	1.192	18	2.13	[illegible]	18	2.16	1.194	19	2.62	1.197	20
14	2.04	1.192	18	2.12	1.192	18				2.16	1.194	19	2.60	1.197	20
15	2.04	1.192	18	2.12	1.192						1.194	19	2.60	1.197	20
[illegible]	2.04	1.190	18	2.12	[illegible]						[illegible]	19	2.60	1.195	20
	[illegible]	1.190	18	[illegible]								19	2.60	1.195	[illegible]
													[illegible]	[illegible]	

24.2 Service Record Sheets

These must be completed at each service operation. Under normal circumstances the Battery Float Voltage will be applied across the battery terminals and the value must be recorded in the space provided. The Average Temperature of Electrolyte must be similarly recorded. If possible, the Battery Charging Current must also be recorded but it may be of such a low value that it cannot be measured easily, if this is the case, enter the letters "CNM" in the space provided.

As required by Section 16, Service Instructions, the individual cell or monobloc float voltage and specific gravities must be recorded on the Service Record Sheets.

An example of a completed record sheet is shown below:-

Service Record Sheet

This Record Sheet must be completed during Service operations.

Tungstone W.O. No F187439		
Customer Ref TB/CB1		
No. of Cells/Monoblocs 24	Type HCP41	Date Installed 18 JAN 93
Installed At ELECTRIC POWER STATION		Battery Title CRITICAL BATTERY № 1
Battery Float Voltage 54·0 V	Average VPC 2·25	Battery Charging Current CNM A
Average Elect Temp 18 °C	Quantity of Water Added NIL	Date of Service 25 JAN 93
Comments: SERVICE NORMAL		
Engineer in Charge ENGINEER A.N. ELECTRIC		

Cell No.	Volts v	Specific Gravity	Cell No	Volts v	Specific Gravity	Cell No	Volts v	Specific Gravity	Cell No	Volts v	Specific Gravity	Cell No	Volts v	Specific Gravity	Cell No	Volts v	Specific Gravity
1	2·25		41			81			121			161			201		
2	2·25		42			82			122			162			202		
3	2·26		43			83			123			163			203		
4	2·24		44			84			124			164			204		
5	2·23		45			85			125			165			205		
6	2·25		46			86			126			166			206		
7	2·27		47			87			127			167			207		
8	2·27		48			88			128			168			208		
9	2·25		49			89			129			169			209		
10	2·24		50			90			130			170			210		
11	2·24		51			91			131			171			211		
12	2·24		52			92			132			172			212		
13	2·25		53			93			133			173			213		
14	2·25		54			94			134			174			214		
15	2·25		55			95			135			175			215		
16	2·25		56			96			136			176			216		
17	2·25		57			97			137			177			217		
18	2·25		58			98			138			178			218		
19	2·25		59			99			139			179			219		
20	2·25		60			100			140						220		
21	2·26		61			101									221		
22	2·26		62			102									222		
	2·24		63			103									223		
			64			104											
			65														

Appendix 1

REQUEST FOR FURTHER INFORMATION

Please send me more details on the following ranges (tick box)	
Tungstone Valve Regulated Lead Acid Cells	
Planté Pure Lead Positive Range of Cells	
Mainstay Pasted Plate Range of Cells	
Tubular Cells	
Nickel Cadmium Cells	
Battery Monitoring	
Installation	
Service and Maintenance of Batteries	
Please arrange for your Regional Sales Manager to call by appointment to discuss Tungstone products.	

Name:
Position:
Address:
Telephone No:
Fax No:

This page is blank so that the form on page 39 may be completed and sent to Tungstone Batteries Ltd.

<u>Appendix 2 - Commissioning and Boost Charge Record Sheet</u> (to be completed)

This Record Sheet must be completed during commission and boost charging.

W.O. No		
Customer Ref		
No. of Cells/Monoblocs	Type	Date Installed
Installed At		Battery Title
Charge Current (see Table 9.1)	A	Date of Charge
Comments:		
Engineer in Charge		

	Time =			Time =			Time =			Time =			Time =		
	Amps =			Amps =			Amps =			Amps =			Amps =		
Cell No.	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C

Appendix 2 - Commissioning and Boost Charge Record Sheet (to be completed)

This Record Sheet must be completed during commission and boost charging.

W.O. No		
Customer Ref		
No. of Cells/Monoblocs	Type	Date Installed
Installed At		Battery Title
Charge Current (see Table 9.1) A		Date of Charge
Comments:		
Engineer in Charge		

	Time =			Time =			Time =			Time =			Time =		
	Amps =			Amps =			Amps =			Amps =			Amps =		
Cell No.	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C	Volts v	Specific Gravity	Electrolyte Temp °C

Appendix 3 - Service Record Sheet (to be completed)

This Record Sheet must be completed during Service operations.

W.O. No		
Customer Ref		
No. of Cells/Monoblocs	Type	Date Installed
Installed At		Battery Title
Battery Float Voltage V	Average VPC	Battery Charging Current A
Average Elect Temp °C	Quantity of Water Added	Date of Service
Comments:		
Engineer in Charge		

Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity
1			41			81			121			161			201		
2			42			82			122			162			202		
3			43			83			123			163			203		
4			44			84			124			164			204		
5			45			85			125			165			205		
6			46			86			126			166			206		
7			47			87			127			167			207		
8			48			88			128			168			208		
9			49			89			129			169			209		
10			50			90			130			170			210		
11			51			91			131			171			211		
12			52			92			132			172			212		
13			53			93			133			173			213		
14			54			94			134			174			214		
15			55			95			135			175			215		
16			56			96			136			176			216		
17			57			97			137			177			217		
18			58			98			138			178			218		
19			59			99			139			179			219		
20			60			100			140			180			220		
21			61			101			141			181			221		
22			62			102			142			182			222		
23			63			103			143			183			223		
24			64			104			144			184			224		
25			65			105			145			185			225		
26			66			106			146			186			226		
27			67			107			147			187			227		
28			68			108			148			188			228		
29			69			109			149			189			229		
30			70			110			150			190			230		
31			71			111			151			191			231		
32			72			112			152			192			232		
33			73			113			153			193			223		
34			74			114			154			194			234		
35			75			115			155			195			235		
36			76			116			156			196			236		
37			77			117			157			197			237		
38			78			118			158			198			238		
39			79			119			159			199			239		
40			80			120			160			200			240		

Appendix 3 - Service Record Sheet (to be completed)

This Record Sheet must be completed during Service operations.

W.O. No		
Customer Ref		
No. of Cells/Monoblocs	Type	Date Installed
Installed At		Battery Title
Battery Float Voltage V	Average VPC	Battery Charging Current A
Average Elect Temp °C	Quantity of Water Added	Date of Service
Comments:		
Engineer in Charge		

Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity	Cell No.	Volts v	Specific Gravity
1			41			81			121			161			201		
2			42			82			122			162			202		
3			43			83			123			163			203		
4			44			84			124			164			204		
5			45			85			125			165			205		
6			46			86			126			166			206		
7			47			87			127			167			207		
8			48			88			128			168			208		
9			49			89			129			169			209		
10			50			90			130			170			210		
11			51			91			131			171			211		
12			52			92			132			172			212		
13			53			93			133			173			213		
14			54			94			134			174			214		
15			55			95			135			175			215		
16			56			96			136			176			216		
17			57			97			137			177			217		
18			58			98			138			178			218		
19			59			99			139			179			219		
20			60			100			140			180			220		
21			61			101			141			181			221		
22			62			102			142			182			222		
23			63			103			143			183			223		
24			64			104			144			184			224		
25			65			105			145			185			225		
26			66			106			146			186			226		
27			67			107			147			187			227		
28			68			108			148			188			228		
29			69			109			149			189			229		
30			70			110			150			190			230		
31			71			111			151			191			231		
32			72			112			152			192			232		
33			73			113			153			193			223		
34			74			114			154			194			234		
35			75			115			155			195			235		
36			76			116			156			196			236		
37			77			117			157			197			237		
38			78			118			158			198			238		
39			79			119			159			199			239		
40			80			120			160			200			240		

HAWKER BATTERIES

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